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Penaeid Prawns in Fanga uta Lagoon, Tongatapu[1]

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ABSTRACT: The penaeid prawns *Penaeus semisulcatus* and *Metapenaeus ensis* were surveyed in Fanga'uta Lagoon, Tongatapu, between July 1975 and August 1976. Catch rates indicate maximum abundance of *P. semisulcatus* from September to November and minimum abundance between January and February. Juveniles were found in March. Maximum abundance of *M. ensis* occurred from mid-October to January and minimum abundance from mid-February to mid-April. Spawning occurred outside the lagoon between January and March, and juveniles were found in the lagoon in late April. All areas of the lagoon show a similar pattern of catch rates. Catch rates of prawns were reduced by one-third during the light phase of the moon, and the full moon appears to be a factor associated with moulting in *M. ensis*.

FANGA'UTA LAGOON, TONGATAPU, is a 7000-acre (2788-hectare) inland brackish water area. Much of the lagoon is very shallow, with depths of 4 ft (1.2 m) or less, but there are some deep channels running through the lagoon. The lagoon serves as a nursery ground for reef fish which support a local subsistence fishery, and it also supports populations of two species of penaeid prawn, *Penaeus semisulcatus* De Haan, 1849 and *Metapenaeus ensis* (De Haan, 1842). The prawns are caught only in small-mesh gill nets set by local fishermen. There is no organized fishery for prawns among the Tongans. In 1974 a businessman began exploiting the prawn populations using a commercial trawl net. Large numbers of juvenile fish were caught and died as a result. This trawling was halted in mid-1975 when lagoon conservation legislation was submitted by the Tongan Fisheries Division and enacted by the Tongan Parliament.

The purpose of this survey, conducted between July 1975 and August 1976, was to collect basic biological information on the two species of prawns and information on seasonal and lunar variations in catch rates.

METHODS

Fanga'uta Lagoon was divided into ten areas on the western, or Nuku'alofa, side of the island and seven areas on the eastern, or Mu'a, side (Figure 1) for purposes of the survey. Five areas (3, 5, 6, 7, 9), all on the Nuku'alofa side, were sampled regularly. Areas 4 and 10 on the Nuku'alofa side and areas 13 and 14 on the Mu'a side were sampled several times but not regularly. The remaining areas (1, 2, and 8 on the Nuku'alofa side and 11, 12, 15, 16, and 17 on the Mu'a side) were not included in the sampling program because of low catch rates, shallowness of water, or presence of coral, mud, or dense turtle grass. The lagoon entrance was not sampled because of rapid tidal currents and scattered coral heads. No sampling was done during December 1975, and only the Mu a side of the lagoon was sampled in November 1975.

Tidal variation was small on the inner part of the Nuku'alofa side of the lagoon [i.e., 10–15 inches (28–38 cm) at full moon], and the tide was nearly 1 hr later inside the lagoon on the Nuku'alofa side than on the ocean front at Nuku'alofa. The state of the tide was not noted during the study but was determined from the phase of the moon at the time of sampling. Trawling was started approximately 1 hr after sunset. Therefore,

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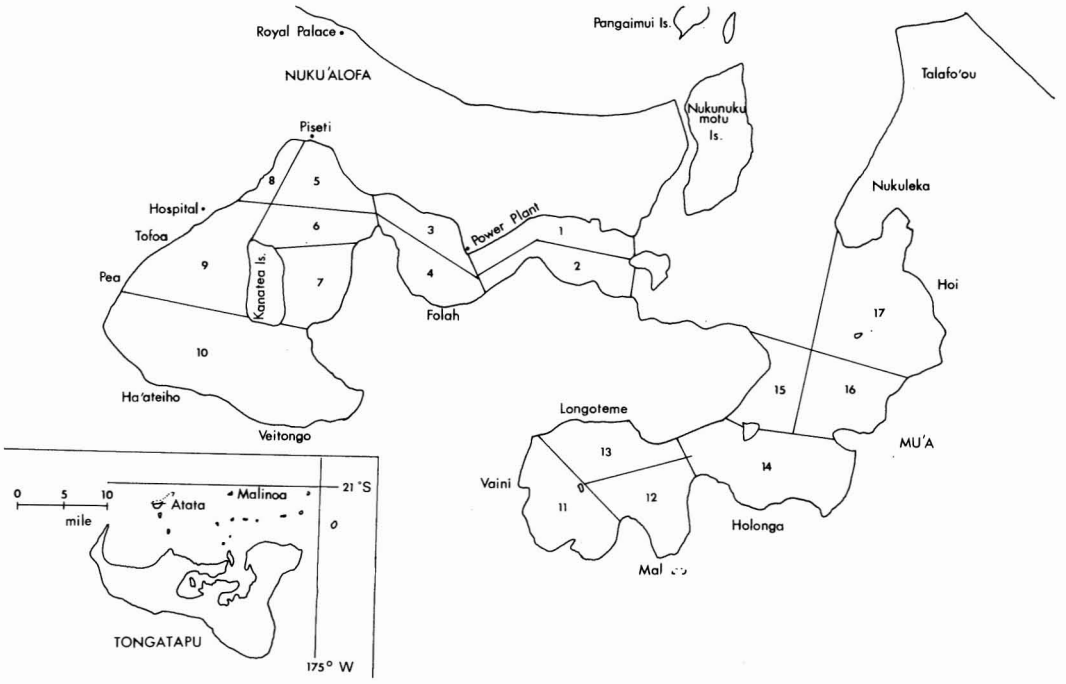

FIGURE 1. Fanga uta Lagoon, Tongatapu, divided into ten areas on the western (Nuku'alofa) side of the island and seven areas on the eastern (Mu'a) side for the 1975–1976 fishery survey. (Scale is in statute miles.)

at full and new moons, trawling began approximately at high tide, and at first and third quarter moons it began approximately at low tide.

Surface water temperatures (Figure 2) that were obtained from area 5 before sampling began on trawling nights ranged from a maximum of 30.2°C in February to a minimum of 20.8°C in late June and early July. Temperatures obtained for other studies in the lagoon showed minimum surface temperatures of 19.5°C during July.

A 25-ft dory with a 15-hp Yanmar inboard engine and a one-man trawl net were utilized in the survey. When the net was opened and being towed, the distance between the otter boards was 10 ft (3 m), and the height of the headrope at its center was about 2 ft (0.6 m). Trawling speed was 2.5 ft/sec (0.76 m/sec) or approximately 1.5 knots. In a standardized 20-min trawl, an area of 0.68 acre (0.27 hectare) was covered. Net mesh was 1 inch (2.5 cm) stretched. Trawling time varied from 90 to 240 min

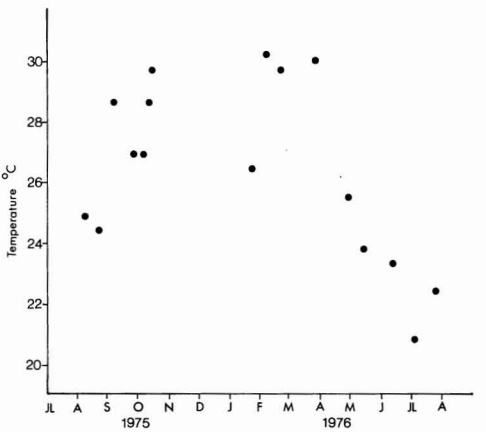

FIGURE 2. Surface water temperatures in area 5, Fanga'uta Lagoon. Temperatures were obtained before sampling began on trawling nights.

with a mean time of 165 min. The actual time the net was sampling varied from 65 to 135 min with a mean of 95 min.

Prawns were measured and weighed in the laboratory after the night's trawling was

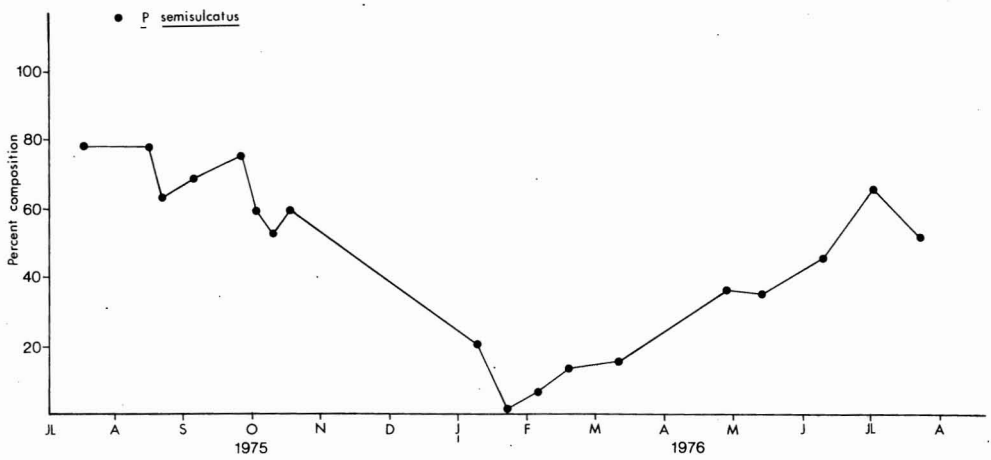

FIGURE 3. Percent species composition of the catch of *Penaeus semisulcatus*.

completed. Ten to 12 specimens of each species were weighed fresh and measured. The number of large, medium, or small-sized prawns of each species was selected dependent upon the percentage of each size group in the night's catch.

RESULTS

The percent species composition of the catch for the sampling period is shown in Figure 3. The figures are for *Penaeus semisulcatus* only and the proportion of *Metapenaeus ensis* was determined from them. During July, when surface water temperatures are lowest, *P. semisulcatus* made up the largest proportion of the catch. As surface water temperatures increase, percent composition changes, and after November *M. ensis* made up the largest proportion of the catch. In late January and early February, few *P. semisulcatus* were caught.

The catch rate, recorded only for the data from the Nuku'alofa side and standardized to 20 min trawling time, is shown in Figure 4. *Penaeus semisulcatus* was more abundant from September to November and at a minimum abundance between the end of January and mid-March. *Metapenaeus ensis* reaches a period of maximum abundance between mid-October and the beginning of January, a little later than *P. semisulcatus*, and minimum abundance occurs between mid-February and mid-April.

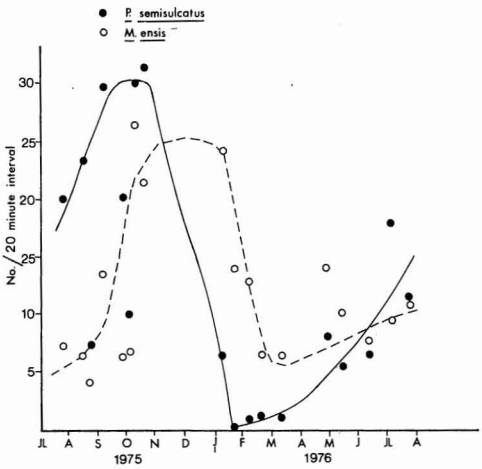

FIGURE 4. Catch rate standardized to 20 min trawling time for prawns caught on the Nuku'alofa side of Fanga'uta Lagoon.

There appears to be only one major migration of prawns from the lagoon to offshore areas during the year. *Penaeus semi-*

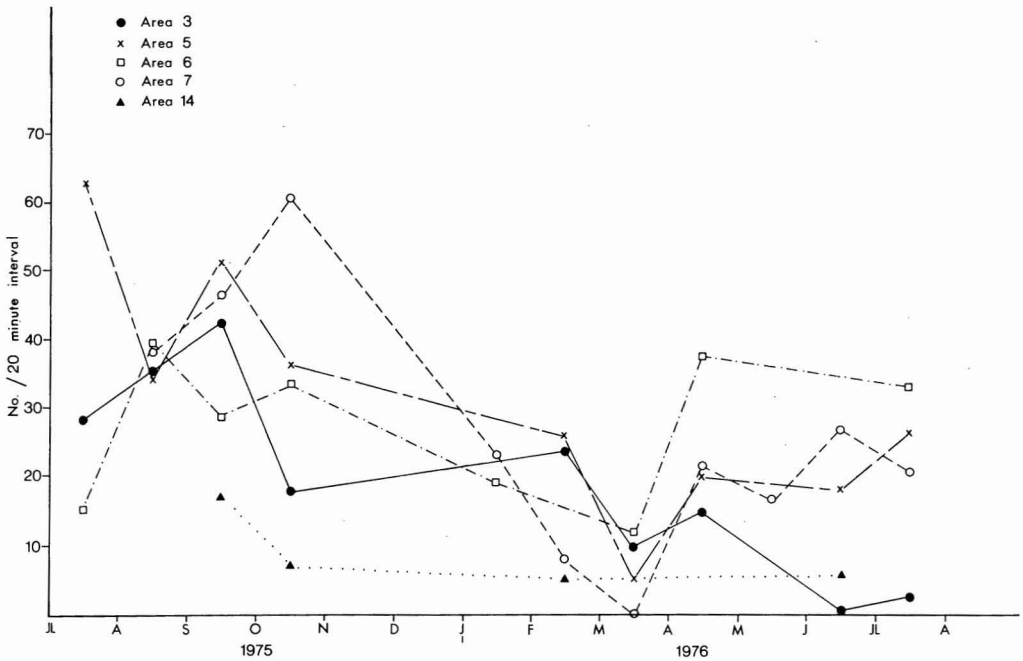

FIGURE 5. Monthly abundance in terms of catch rates standardized to 20 min trawling time for five areas of Fanga'uta Lagoon.

sulcatus began migrating out from the lagoon in October and spawning offshore probably occurred between November and February. The catch rate began to increase again in March as juveniles entered the lagoon from offshore spawning grounds (Figure 4). *Metapenaeus ensis* moved out of the lagoon from the beginning of January to March. The catch rate increased in late April as the juveniles entered the lagoon (Figure 4).

Monthly abundance in terms of catch rate is shown in Figure 5. The same general pattern is seen in all areas of the lagoon. The highest total catch rate occurred between September and November and the lowest catch rate was in March. These data suggest that the prawns did not move to different areas of the lagoon but were migrating out of the lagoon and spawning.

There were two distinct size peaks during the year for each species (Figure 6). Mean length of *Metapenaeus ensis* increased from July to a peak in September and the begin-

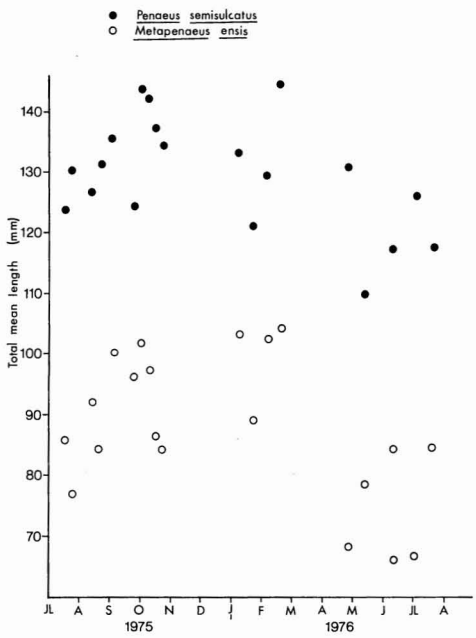

FIGURE 6. Size of prawns and time in Fanga'uta Lagoon.

ning of October and then declined, and mean length was again at a maximum from January to mid-February and then decreased. Some migration of adults out of the lagoon may have begun in October which would account for the decrease in length. However, the peak from January to mid-February coupled with the data shown in Figure 4 suggest that the main migration began after the January peak in size. The minimum mean length reached in late April suggests that juveniles from the offshore spawning were entering the lagoon. Mean size range of *M. ensis* was 6.6–10.4 cm. The period of growth in the lagoon was about 5 months, with little apparent growth between October and February.

Mean length of *Penaeus semisulcatus* increased from July to the beginning of October. It then decreased through January (Figure 6). In October, migration of adults out of the lagoon began, leaving subadults with a consequent drop in mean length and catch rate (Figure 4). From January until mid-Febrary the mean length again increased to a peak as high as the first peak in October, suggesting that the subadults had reached adult size and were migrating out of the lagoon. Although only a few individuals were represented in the January and February samples (Figure 4), all were adults. Mean length again decreased until it reached a minimum in mid-May with a subsequent increase through July. As with *Metapenaeus ensis*, these data suggest that the juveniles were entering the lagoon, and small juveniles were found in the May catch and larger ones thereafter. The increase in mean length from May to August represented growth of juveniles and subadults. The period of growth in the lagoon was about 5 months (May to October). Mean size of *P. semisulcatus* ranged from 11.0 to 14.4 cm.

Length–weight data are shown in the following regression equations:

$$\text{Weight} = 4.3 \times \text{Length} - 33.7 \text{ for } \textit{P. semisulcatus}$$

$$\text{Weight} = 1.7 \times \text{Length} - 8.4 \text{ for } \textit{M. ensis}$$

Standardized abundance of total prawn catch and moon phase are shown in Figure 7. There appears to be a correlation between amount of light and catch rate: Catches were about 33 percent lower during the light phase of the moon. However, considerable avoidance may have occurred because of the small size of the trawl net used, with avoidance dependent on light intensity which in turn was dependent on moon phase. Or the prawns may have burrowed deeper in the mud bottom during the light phase of the

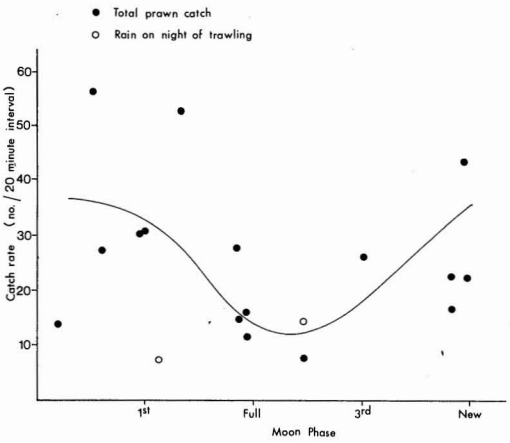

FIGURE 7. Catch rate standardized to 20 min trawing time and moon phase in Fanga'uta Lagoon.

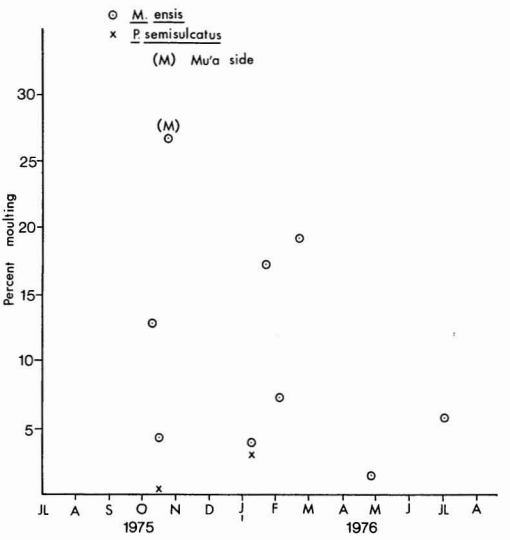

FIGURE 8. Moulting and time for *Metapenaeus ensis* and *Penaeus semisulcatus* in Fanga'uta Lagoon.

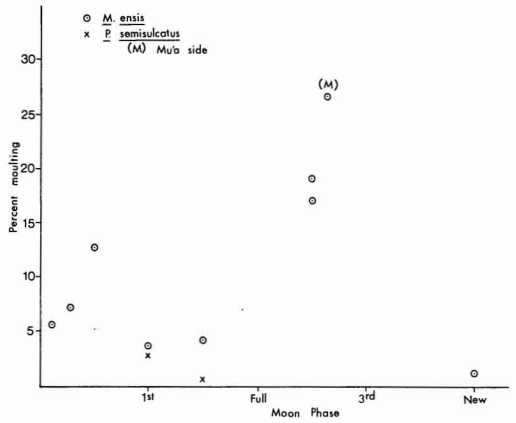

FIGURE 9. Moulting and moon phase for *Metapenaeus ensis* and *Penaeus semisulcatus* in Fanga'uta Lagoon.

moon than in the dark phase, thus avoiding capture.

Moulting (Figures 8 and 9) appears to be associated with phase of the moon. The first soft-shelled prawns were found in mid-October 1975, and the last were noticed at the beginning of July 1976. Percent occurrence was highest in October when moulting began. Moulting was noticed only twice for *Penaeus semisulcatus*, in October and again in late January. In *Metapenaeus ensis* highest percentages were found in trawls after the full moon.

No data were kept on sex ratios during this study, but most *Metapenaeus ensis* examined at irregular periods were immature females.

DISCUSSION AND CONCLUSIONS

Comparison of the migration and spawning data for *Penaeus semisulcatus* in the Fanga'uta Lagoon, Tongatapu, with those for the prawn elsewhere in the Indo-Pacific indicates some similarities. In Pulicat Lake, about 13° N latitude on India's east coast, three species of penaeids, *P. indicus*, *P. monodon*, and *P. semisulcatus*, have their predominant peak of postlarval abundance in March and April (Gopalakrishnayya and Rao 1975). The postlarvae of *P. mondon* immigrate into Pulicat Lake from July to November and in March and April. Similarly, the postlarvae of *P. semisulcatus* immigrate into the lake from August to October and in March and May–June (Rao and Gopalakrishnayya 1974). Offshore from Pulicat Lake there must also be a second spawning in June and July because postlarvae enter the lake from August to October, as well as in March to May–June. Latitude (and, by implication, water temperature and maturation rates) may indicate whether one or two generations per year is represented in an area.

In the Persian Gulf, *Penaeus semisulcatus* spawns from November to March and lives for 1 year in the Gulf. The population is therefore represented by prawns of one generation (Drobysheva and Aseev 1976), and the population density is subject to large annual fluctuations. In Tonga, *P. semisulcatus* and *Metapenaeus ensis* spend about 7 and 9 months, respectively, in the Fanga'uta Lagoon before migrating offshore and spawning. Conversely, in Pulicat Lake, *P. semisulcatus* postlarvae migrate into the lake for 3 months, and again for 4 months, and there should be less annual fluctuation in the population density of prawns in Pulicat Lake than in Tonga because of the two generations represented per year compared with the single generation in Tonga.

Lunar periodicity is known to induce production of moulting hormones and to trigger spawning in marine invertebrates. For *Metapenaeus bennettae* in Australia periodicity is more pronounced in females when they shed their shells in the summer months during full moon cycles (Racek 1972). Similarly, in Fanga'uta Lagoon the light moon phase appears to be of importance in the biorhythms of the prawns associated with spawning and moulting.

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